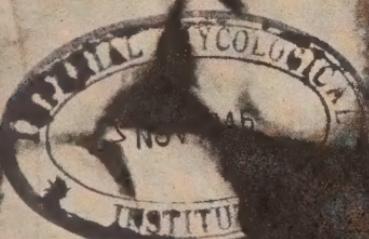


1946



Cotton Boll Rots IN OKLAHOMA

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COTTON BOLL ROTS IN OKLAHOMA

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Boll rots constitute a serious problem in cotton culture. They produce a premature shedding of the boll or failure of the locks to open, thus seriously reducing the yield. They also often reduce the grade and value of cotton by staining and spotting or matting the lint and weakening the fiber strength.

Investigation of boll rots at this Station over a period of three years has shown that the fungi which causes rot can get into bolls only through holes made by mechanical injury, by boll worms or other insects, or by an attack of bacterial blight. Therefore boll rotting can be greatly decreased by controlling insects, especially boll worms, and by reducing bacterial blight.

In addition to causing boll spot and decay, the bacterial blight disease may result in poor stands; seedling blight in which the stems or primary leaves or both may be affected; angular leaf spot which often causes defoliation; and black arm or stem rot.

BOLL ROT CONTROL

Bacterial blight in the seedling stage can be controlled, completely or almost completely, by chemical seed treatment.*

Treatment of fuzzy seed with organic chemical dusts will inactivate fungi and blight bacteria carried on the seed and will also protect it from attacks by soil organisms after it is planted. Chemicals which have proved to be superior and dependable for this purpose include 2% ethyl mercury chloride (Ceresan), 5 % ethyl mercury phosphate (New Improved Ceresan), 7.7% ethyl mercury p-toluene sulfonanilide (Dugay 1452-F) and the zinc salt of 2, 4, 5-trichlorophenol (Dow 9).

Seeds treated with concentrated sulphuric acid to remove the fuzz are freed of surface-borne organisms, including the blight bacteria, but do not carry a protective coating into the soil unless they are dusted. However, dusting is greatly simplified by preliminary delinting.

*The principal means of carrying over the blight bacterium from season to season is on the surface of the seed or in the fuzz. Internal infection of seed occurs rarely. Carry-over in the soil has not been satisfactorily demonstrated, but indirect evidence indicates this possibility.

Methods of dusting cotton seed are described in more detail in Oklahoma Station Circulars C-89, "Seed Treatments of Cotton," and C-296, "Protecting Cotton from Insects and Plant Diseases."

Dry weather holds the bacterial blight disease in check and thereby reduces the prevalence of boll rotting. Cotton growing in rich bottom land, where vegetative growth is rank, sunlight is excluded and good ventilation is lacking, is more subject to bacterial boll blight and other boll decays than cotton growing in more exposed places and having thin vegetative growth.

Seed treatment protects the cotton plant against blight in the seedling stage only, and later infections may occur. However, by reducing to a minimum or eliminating entirely the early seedling infection stage, the subsequent chance of infection in older plants is correspondingly reduced. Wind-blown rain, running water, and dust storms have all been demonstrated as agents for the introduction of blight into fields that have previously been free of infection, or where infection has been limited to a few plants scattered in the field.

The appearance of blight later in the season in fields planted with treated seed is another serious problem, and it may eventually be solved by the breeding of blight-resistant varieties. This problem is already being investigated at this Station and at several of the federal cotton stations, and the future for the development of resistance to blight in cotton is bright.

EXPERIMENTAL WORK ON CAUSES OF BOLL ROTS

Organisms Associated with Boll Rots in Oklahoma

SURVEY METHODS

Rotted boll samples were collected in 1942, 1943 and 1944 and the organisms responsible for the decay isolated and identified. Only bolls having small lesions rather than those in which the entire boll was involved in decay were taken. Generally, at least 10 bolls were collected in each field sampled. A small portion of the lesion (0.5 x 1 cm.) was cut out and disinfected for 3 to 5 minutes in a calcium hypochlorite solution having 2 percent available chlorine. The treated pieces were placed on water agar in petri dishes. If bolls had more than one lesion, a corresponding number of isolations was made. Identifications were made, whenever possible, directly from the original plates, but some were made from subcultures at a later time.

FREQUENCY OF OCCURRENCE OF VARIOUS FUNGI

The tabulated results for each of the three years of the surveys are presented in Tables 1 to 3 and summarized in Table 4. Although the bacterial blight organism, *Xanthomonas malvacearum*, is not included in the tables (since this project emphasized the fungi causing boll rots), laboratory tests and observations in the field showed this organism present in a large proportion of the lesions. Frequently typical bacterial lesions but a few days old yielded fungi. In the light of the infection tests, described on page 10, it is apparent that the blight bacterium is the most important primary invader of boll tissues in Oklahoma, whereas the fungi are secondary in nature and require some deterioration of the tissues before they can invade.

TABLE 1.—Frequency of occurrence of fungi associated with rotted bolls collected in 11 counties of Oklahoma in 1942.

	Distribution of the fungi			
	In 27 Samples		In 233 Bolls	
	Number	Percent	Number	Percent
Alternaria spp.	27	100.0	142	60.16
Aspergillus niger	4	14.8	10	4.24
Curvularia spp.	4	14.8	5	2.12
Fusarium moniliforme	9	33.3	18	7.63
Fusarium spp.	18	66.6	47	19.92
Glomerella gossypii	3	11.1	6	2.54
Penicillium spp.	2	7.4	2	0.85
Rhizopus nigricans	3	11.1	2	0.85
Other fungi	3	11.1	4	1.69

TABLE 2.—Frequency of occurrence of fungi associated with rotted bolls collected in 10 counties of Oklahoma in 1943.

	Distribution of the fungi			
	In 14 Samples		In 105 Bolls	
	Number	Percent	Number	Percent
Alternaria spp.	14	100.0	78	57.35
Aspergillus niger	5	35.7	10	7.35
Curvularia spp.	1	7.1	1	0.74
Fusarium moniliforme	13	92.9	25	18.38
Fusarium spp.	9	64.3	19	13.97
Glomerella gossypii	0	0.0	0	0.00
Penicillium spp.	1	7.1	1	0.74
Rhizopus nigricans	2	14.3	2	1.47
Other fungi	0	0.0	0	0.00

TABLE 3.—Frequency of occurrence of fungi associated with rotted bolls collected in 26 counties of Oklahoma in 1944.

	Distribution of the fungi			
	In 29 Samples		In 242 Bolls	
	Number	Percent	Number	Percent
Alternaria spp.	29	100.0	412	67.21
Aspergillus niger	11	38.0	45	7.34
Curvularia spp.	3	10.3	5	0.81
Fusarium moniliforme	15	51.7	37	4.03
Fusarium spp.	18	62.0	59	9.62
Glomerella gossypii	1	3.4	2	0.32
Penicillium spp.	4	13.8	13	2.15
Rhizopus nigricans	5	17.2	11	1.79
Other fungi	10	34.4	29	4.73

TABLE 4.—Summary of the frequency of occurrence of fungi associated with rotted bolls in 34 counties of Oklahoma.

	Distribution of the fungi			
	In 70 Samples		In 580 Bolls	
	Number	Percent	Number	Percent
Alternaria spp.	70	100.0	632	64.2
Aspergillus niger	20	28.6	65	6.6
Curvularia spp.	8	11.4	11	1.1
Fusarium moniliforme	37	52.9	80	8.1
Fusarium spp.	45	64.3	125	12.7
Glomerella gossypii	4	5.7	8	0.8
Penicillium spp.	7	10.0	16	1.6
Rhizopus nigricans	10	14.3	15	1.5
Other fungi	13	18.6	33	3.4

The frequency of occurrence of the various fungi as determined in the three-year survey corresponds favorably with a nationwide survey conducted over a period of years by the Division of Mycology and Disease Survey and recorded by Miller (9, 10) and Miller and Weindling (11, 12, 13). They point out that the anthracnose disease, caused by *Glomerella gossypii*, is rare in Oklahoma and Texas but becomes increasingly more important eastward. The absence of this disease from all but the eastern edge of Oklahoma and Texas appears to be correlated with the amount of rainfall, being rare or absent where 40 inches or less are received annually. The 40-inch line runs parallel to Oklahoma's eastern border and lies about 50 to 100 miles to the west (Fig. 1).

Miller and Weindling report finding the anthracnose fungus in McCurtain, Sequoyah, Lincoln, Tulsa and Pushma-

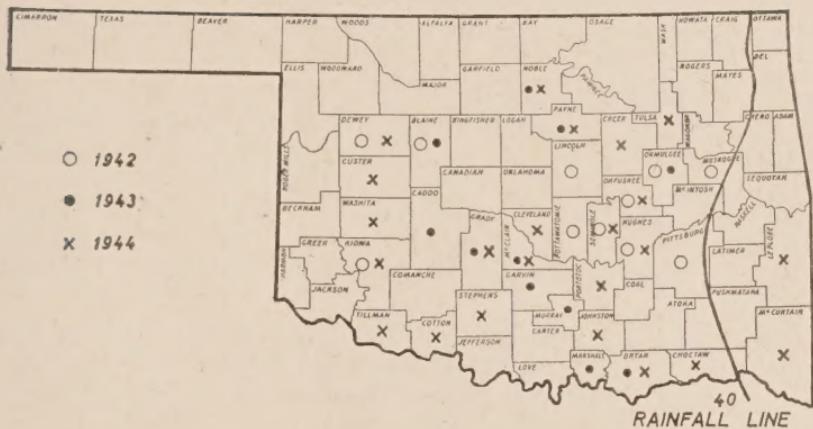


Figure 1.

taha counties. The writer found it in Muskogee, Okfuskee, LeFlore, and Lincoln (14, 15). Thus, the fungus is known to occur in only eight Oklahoma counties, but its importance as a boll rotting organism is negligible because of its infrequent occurrence. The counties from which samples were collected are shown in Figure 1.

Alternaria spp., a common type of sooty mold occurring on all kinds of substrata, constituted the largest percentage of the fungi isolated in the three-year Oklahoma survey (64.2%) and in the four-year federal survey (67.8%). Members of this group are strictly secondary invaders following invasion of the bacterial organism or insect punctures, but they are rather active boll rotters.

Aspergillus niger and *Rhizopus nigricans*, often called black molds, are very rapid in their rotting activities, often causing complete deterioration within a few days. They may be more prevalent than the data indicate in the tables if it is remembered that specimens selected for isolations had small lesions rather than a wide-spread rot.

Curvularia spp. are also sooty molds and behave somewhat like *Alternaria* with respect to boll-rotting activities.

Fusarium moniliforme, a common pink mold, although the fungus most frequently isolated from cotton seedlings (16), is not so abundantly associated with boll rots. Other members of the *Fusaria* are likewise commonly associated with boll rots. Probably all of these *Fusaria* are secondary invaders.

"Other fungi" made up a diverse group and included such fungi as *Penicillium*, *Diplodia*, *Macrophomina phaseoli*, and sterile forms.

EFFECT OF WEATHER CONDITIONS

The 1943 growing season was dry in comparison to those of 1942 and 1944. In that year the writer had difficulty collecting adequate samples, and some fields were examined in which boll rots were entirely absent. The bacterial blight disease was held in check by the dry weather, and its failure to develop directly affected the number of secondary fungous invaders.

Observations indicate that local rainstorms have much to do with the spread of the bacterial disease and the frequency of its occurrence. As an example, a breeding plot of the Oklahoma Triumph variety at Perkins, Oklahoma, was subjected to two 3-inch rains at the time the first bolls were setting on, and the lesions on the leaves and bolls were extremely numerous. The same variety from the same seed source at Stillwater, Oklahoma, ten miles away where the two heavy rains did not occur was very little affected by blight (15). Miles (8) reports a serious outbreak of the disease in Mississippi after a severe tropical rain storm followed by several days of cloudy weather. Blodgett (2) reports a severe outbreak of bacterial blight in a region of Texas involved in a Gulf storm characterized by heavy rainfall and high winds. The heaviest infection occurred where the storm damage was the greatest and where the rainfall was two inches during the twenty-four hours of the storm. Brown (3), Rolfs (17), and Faulwetter (6) emphasize the importance of rain in the development of bacterial blight, and Stoughton (21) finds maximum infection occurring at humidities exceeding 85 percent.

Infection Experiments

METHODS OF INOCULATION

Plants for the infection tests were grown in the greenhouse during the winter and in the field during the summer. Bolls selected for infection studies were half-grown. If very young bolls were used, the process of inoculation, which in some cases involved injuring the bolls by puncturing, often caused them to shed prematurely. On the other hand, if bolls were too advanced in development, the lesions would not develop completely before the bolls opened.

In nearly all cases bolls were wiped with a piece of cotton saturated with 95% ethyl alcohol and allowed to dry before the inoculum was applied. Two principal methods of inoculation with fungi were employed:

1) A block of agar, approximately 0.8 x 0.8 cm., cut from a plate containing an active young growth of the fungus, was placed mycelium-side down on the surface of the boll. A sharp, slender needle was driven through the block of inoculum several times if infection by means of injury were desired, or if not, the block was not pierced. A small paper bag containing a wad of water-soaked cotton was fastened over the inoculated boll and left for two days.

2) Heavy spore suspensions were made by adding sterile distilled water to petri dish cultures. Glass pipettes with very slender points were used to inject the spore suspension into the interior of the bolls.

These same methods were used in inoculating with the bacterial organisms, but several additional techniques also were employed: 1) a heavy growth of bacteria was smeared lightly over the boll with the fingers, 2) bolls were sprayed with a bacterial suspension, and 3) bolls were submerged in a suspension of bacteria for one hour.

RESULTS WITH VARIOUS ORGANISMS

Alternaria spp. Members of this group of fungi are commonly known as "sooty molds" because of the sooty-looking masses of spores. Many references to *Alternaria* occurring on cotton leaves and bolls may be found in the literature. Although several named species have been recorded occurring on cotton, nearly all of the isolates examined by the writer fall within the concept of *A. tenius* Auct. as suggested by Wiltshire (23).

Infection could be easily obtained by puncturing the boll or by injecting spores into the interior. The external tissues of the boll did not decay as rapidly as those of the interior. Eleven days after inoculation, the diameter of the lesion on the surface was between one-quarter and one-half inch. The lesion was slightly depressed and dark brown in color (Plate 1, A). In the greenhouse, mycelium appeared at the puncture and a few spores were produced. The lint and the seeds deteriorated and became chocolate-brown in color (Plate 1, B).

Because of the frequency of its occurrence and the speed with which it causes decay of the lint and seed, *Alternaria* can be rated as the principal cause of boll decay in Okla-

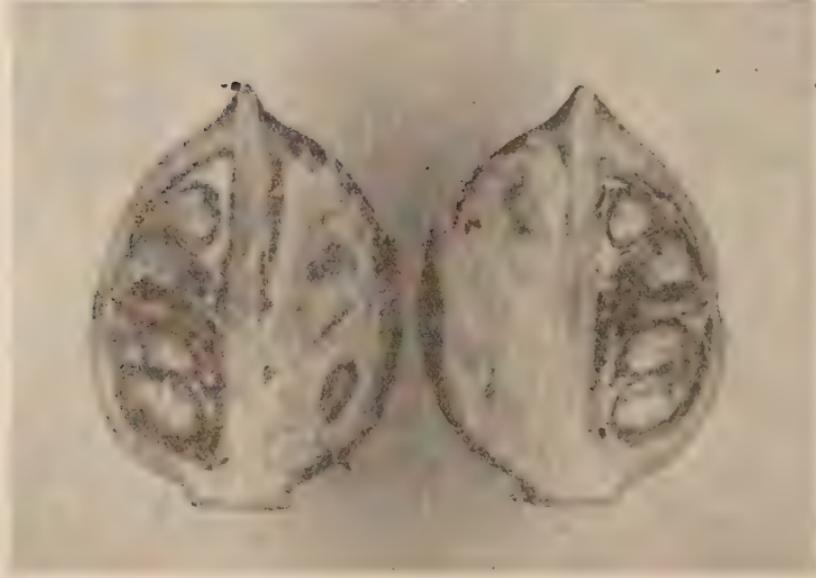


Plate 1, A and B. Bolls injected at one point only with spore suspension of *Alternaria* sp. after 11 days.

homa. This is despite the fact that *Alternaria* is not a primary but rather a secondary invader, and its entrance is dependent on primary invasion by the blight organism or mechanical injury.

Aspergillus niger. Like the *Rhizopus* decay of bolls, the *Aspergillus* decay has been referred to as "smut" because of the black spore masses of the fungus which sometimes form on the surface of the lesion. The symptoms of this disease have been clearly described by Shapovalov (18). Perhaps the outstanding characteristic of the young lesion is its pinkish color. As the lesion increases in size the central area becomes brown and only the margin remains pink. Although this fungus does not cause as rapid deterioration as *Rhizopus*, it is the second most active organism of those tested. Lesions covering a quarter to a half of the surface area may develop within a week from a single point of inoculation (Plate 2, A). Deterioration of the internal tissues is equally rapid, and these tissues become soft, decayed, and have various shades of brown and purple (Plate 2, B).

Aspergillus decay was observed in the field to occur principally around insect punctures, especially those made by the boll worm. The fungus was, however, also isolated from lesions initiated by the bacterial blight organism. Pathogenicity tests showed that *Aspergillus* readily caused boll infection through wounds, but negative results were obtained when the tissues were not punctured. The fungus sporulated on the surface of the lesions when the atmospheric humidity was high.

Curvularia spp. These fungi, like the *Alternariae*, are called "sooty molds", but unlike them they are associated only occasionally with boll rots.

Bolls inoculated with an isolate of *Curvularia* became decayed only when spores were injected into the interior of the boll or when the fungus was permitted to gain entrance by means of punctures made with needles. Deterioration of the external tissues was very slow, and was characterized by a slight sinking and browning of the tissues (Plate 3, A). Decay internally was likewise slow and involved but a small amount of the lint and seeds, which became soft and a red-brown and purple (Plate 3, B).

Spores were produced on the surface of the lesions if plants were produced in the greenhouse under conditions of high humidity.



Plate 2. A and B. Bells injected at one point only with a spore suspension of *Aspergillus niger*, after 6 days; note the black mass of spores on the surface of the lesion in A.

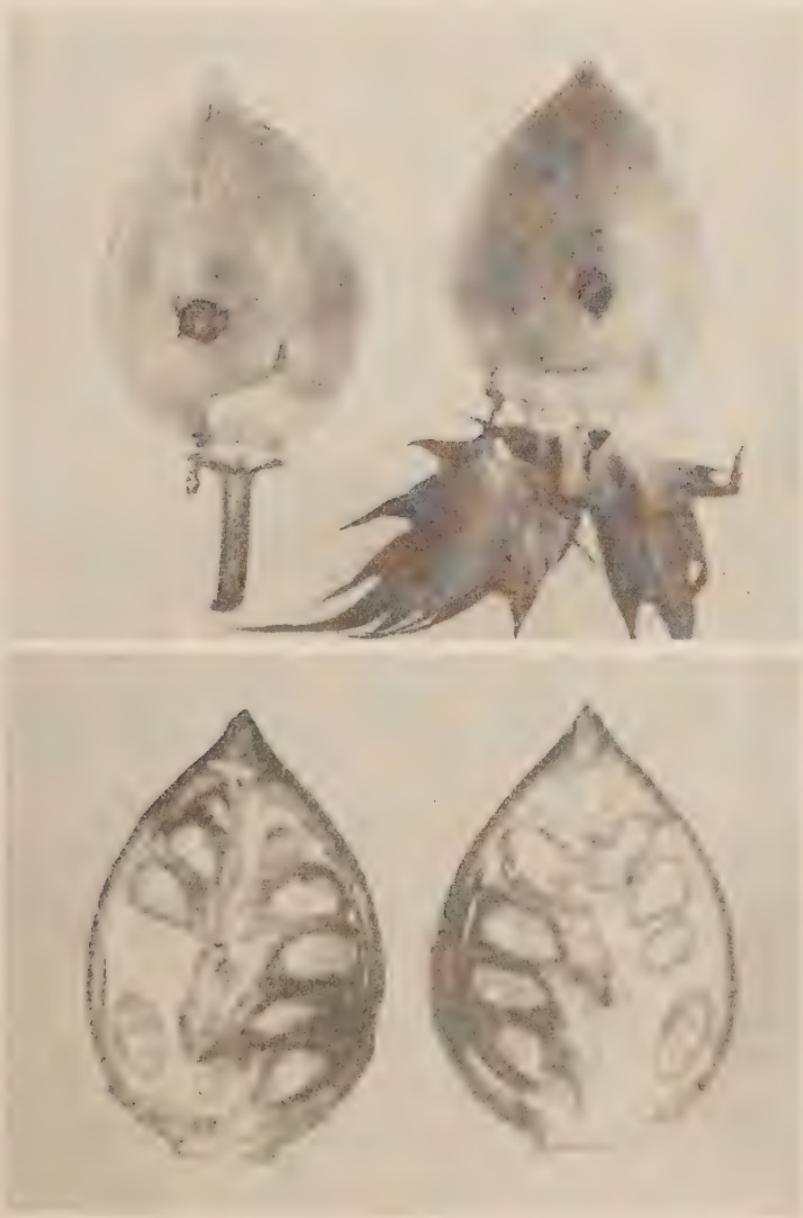


Plate 3, A and B. Bolls injected at one point only with spore suspension of *Curvularia* sp. after 6 days.

Fusarium moniliforme. This fungus, because of the pinkish color of its spores in mass, could be called a "pink mold." Its frequency of occurrence on bolls is considerably less than on roots where it acts as a weak parasite (16).

This pink mold caused rather rapid decay of the exterior and interior regions of the boll, being only slightly less active than *Aspergillus niger*. Infections occurred only through punctures or by injection of spore suspensions into the lint cavity, and attempts to cause infection in uninjured bolls failed. The lesions were slightly depressed, at first a pink to purplish-brown in color, but later the central region became brown with only the margin remaining brightly colored (Plate 4, A). Decay internally was somewhat more rapid than on the surface. The lint and seed deteriorated into a uniform brown mass of tissue (Plate 4, B).

The mycelium of the fungus first appeared on the surface as a white, cottony mass, but became pinkish when spore production took place.

Glomerella gossypii. It has been demonstrated by Edger-ton (4, 5) and by Barre (1) that the anthracnose fungus, *Glomerella gossypii*, is able to cause infection in young bolls and flowers directly through uninjured tissues. Weindling and Miller (22) also demonstrated primary invasion by this fungus, but discovered that mixture of the bacterial blight organism and the anthracnose fungus produced more lesions than did the anthracnose fungus alone. They concluded that infection of bolls with the anthracnose fungus is frequently made possible by the bacterial organism.

Although the writer attempted to cause infection of uninjured bolls by placing agar blocks containing the fungus on the boll surface, none was positive in either the greenhouse or field tests. The bolls were not very young, which may explain the failure to produce lesions. Agar blocks placed on bolls and punctured with a needle resulted in infections in nearly all cases. Spore suspensions injected into bolls by means of glass pipettes produced lesions on the surface and deterioration of the internal tissues in every instance.

This fungus causes rotting of the exterior and interior boll tissues at approximately equal rates. The lesions are somewhat circular, depressed, and brown to black (Plate 5, A). Masses of pasty pink spores appeared on the surface of lesions of greenhouse plants, where the humidity was high, but spore masses did not occur in the field. When infected bolls were cut, the lint and seeds were found to have rotted

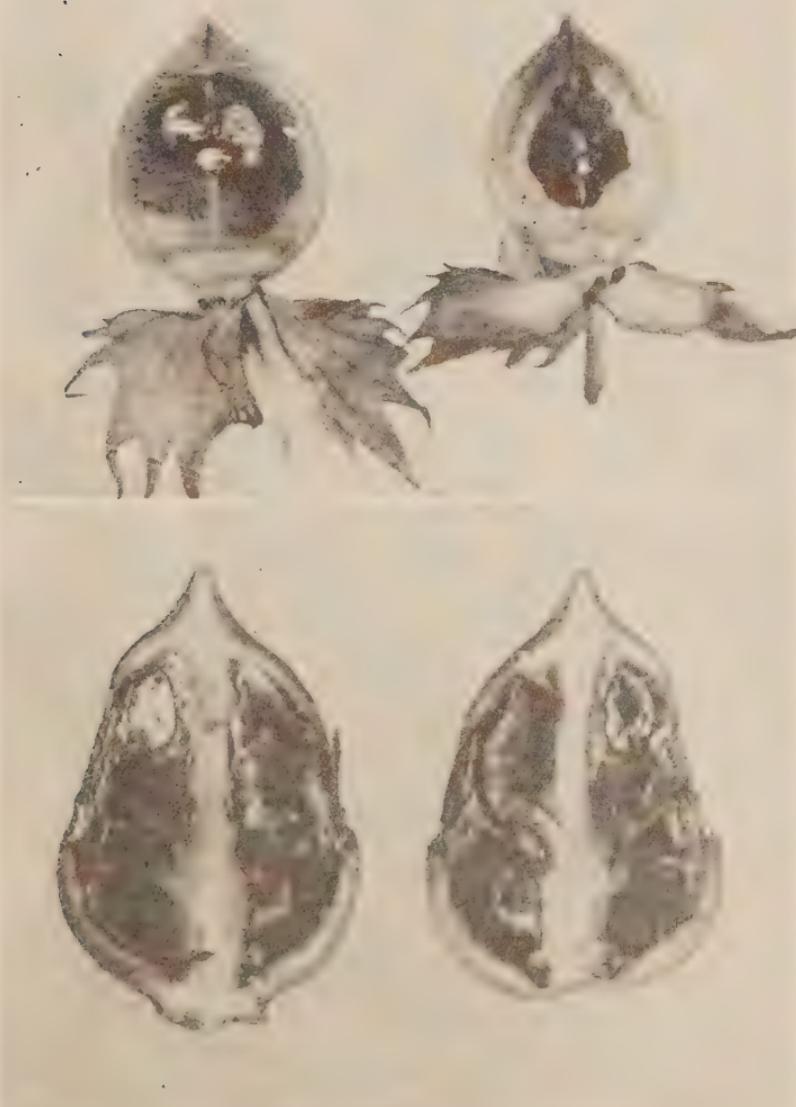


Plate 4. A and B. Bolls injected at two opposite points with spore suspension of *Fusarium moniliforme*, 11 days after inoculation; spores are present on the bolls, surface in A.

severely, and the color of the affected tissues was a reddish-brown (Plate 5, B). When bolls were completely rotted, they were hard and brownish-black.

Rhizopus nigricans. This fungus has often been referred to as the "black bread mold" and in connection with boll decay has been called "smut". In the field the boll rot caused by this fungus is most frequently associated with insect injury, particularly that of the common boll worm. Perhaps the reason this organism has not been collected and isolated more frequently is because of the rapidity with which it destroys bolls. It destroyed bolls more quickly and completely than any of the other organisms tested. Nearly all the samples collected in the survey had only small lesions, and badly rotted bolls were not included. It may be that this fungus is more important as a boll rotter in Oklahoma than is evident from the survey data. *Rhizopus* rot has been known for many years and extensive studies have been made of it by Kirkpatrick (7) in Egypt and by Shapovalov (18) in this country. These investigations emphasized the association of this rot with worm injury.

Attempts to cause lesions on uninjured bolls were not successful, but boll rotting occurred in nearly every instance when the boll was punctured or when spores were injected into the boll cavity. Infected bolls became dull olive green to tan and felt sticky. Complete decay of the exterior and interior tissues (Plate 6, A) took place within three days under ideal conditions in the greenhouse, whereas in the field about one week was required. No other organism tested produced deterioration at so rapid a rate. After the capsule is completely affected, it becomes brown, dry, and remains firmly attached for some time. Lint and seed in the early stages of decay are soft, pasty, and creamy white. Later the color changes to a greyish purple with some pink and yellow color present in the decaying seeds (Plate 6, B).

Xanthomonas malvacearum. The disease caused by this bacterial pathogen is the most prevalent and destructive of all in Oklahoma and Texas and in the western cotton areas. The organism is seed-borne, principally in the fuzz, and may cause seedling blight, leaf blight (angular leaf spot), black arm or stem blight, and boll decay.

Many workers such as Smith (19), Edgerton (4), Stoughton (20), and Weindling and Miller (22) have demonstrated that this organism is a primary invader, invasion occurring principally through the stomata. In greenhouse and field tests the writer was able to produce lesions readily on unin-



Plate 5, A and B. Bolls injected at one point with spore suspension of *Gloomerella gossypii*, 6 days after inoculation.

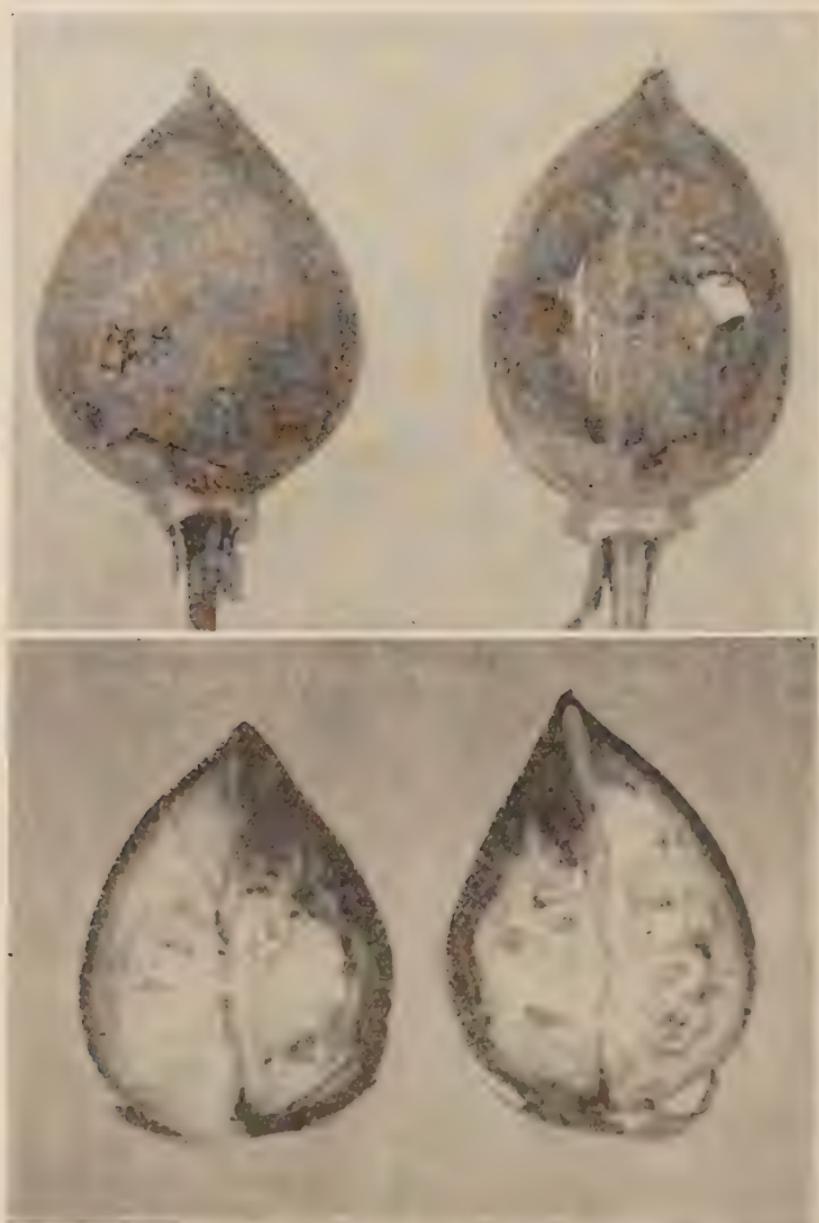


Plate 6, A and B. Bolls injected at one point with spore suspension of *Rhizopus nigricans*, 3 days after inoculation; entire boll is rotted.

jured bolls by several methods: 1) rubbing a heavy growth of bacteria lightly over the bolls with the fingers, 2) spraying the bolls with a heavy suspension of bacteria, and 3) submerging bolls in a bacterial suspension for one hour.

When needle punctures were made through a bacterial smear, infection occurred around the hole in a high percentage of the cases.

Young lesions on bolls first appeared as slightly raised, water-soaked, circular spots (Plate 7, A). As the spots increase in size, they become concave, the central area becomes brown, but the margin remains water-soaked. Eventually the entire lesion becomes brown to brownish-black (Plate 7, B). As soon as the central portion of the lesion becomes brown, fungi of various kinds can be recovered in nearly every instance, and occasionally fungi can be recovered before browning begins. Ordinarily bacterial lesions are rather shallow and do not penetrate into the boll cavity unless fungi are associated with the bacterial pathogen. When bacteria are injected into the boll cavity, the lint deteriorates, becoming yellowish and matted. Rotting activities are not very rapid.

Tests of Effectiveness of Chemical Dusts

Although the writer has often observed the absence of blight in seedlings from treated seed in contrast to considerable blight in seedlings grown from nontreated seed, no actual data were recorded. Therefore a few simple tests were made to provide data showing the effectiveness of chemical dusts for controlling bacterial blight of seedlings produced from artificially infested seed.

In 1944 tests were made in the field. Acid-delinted seed of Deltapine 14 and Stoneville 2B were dipped in a bacterial suspension for 15 minutes. After drying in the air on blotters, one-half the seeds of each variety were treated with New Improved Ceresan while the other half were left untreated. Each of the four lots was planted in a block of 12 rows 20 feet long and was replicated twice. Counts were based on two hundred seedlings selected at random in each plot at thinning time. A single lesion on the primary leaf was sufficient to classify the plant as infected.

In 1945 additional tests were conducted in the greenhouse. Fuzzy seed of the variety Hi-Bred was placed in a suspension of bacteria and kept agitated for 20 minutes, after which the seed was spread out to dry on paper toweling. When

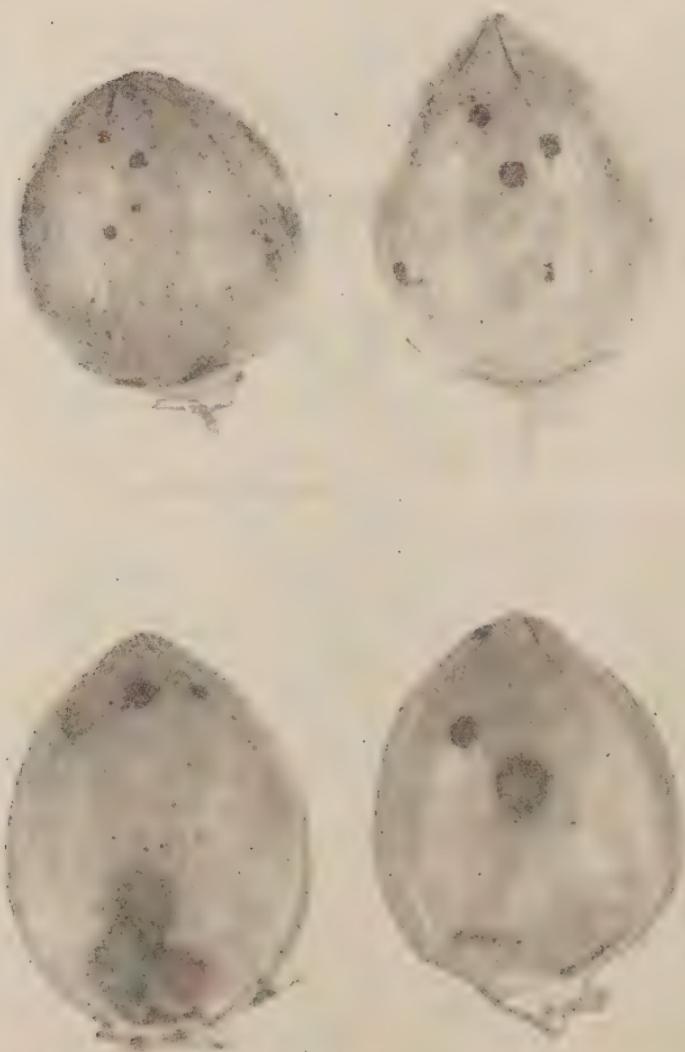


Plate 7. A. Early stages of infection by *Xanthomonas malvocearum*. B. Later stages of infection by *X. molvocearum*; lesions nearly always contain secondary fungi at this stage.

thoroughly dry, the seed was divided into two lots; one was treated with New Improved Ceresan and the other left untreated. The experiment was repeated three times. Each time the seed was planted in wet sand in flats in the greenhouse and counts were made one week following planting.

The results of the field tests made in 1944 with two varieties are shown in Table 5. The results of the tests with the fuzzy Hi-Bred seed in the greenhouse are presented in Table 6. The appearance of a few plants showing bacterial lesions in the case of the treated Hi-Bred seed in no way detracts from the benefit imparted by the use of this chemical. The infections may have occurred because some of the fuzzy seed were cracked, so that while soaking in the bacterial suspension, a certain amount entered through the seed coat, and seed treatment is not effective against internally borne organisms. Another possible explanation is that natural internal infection already existed at the time of soaking and treating. Neither of the above possible explanations would aptly apply to acid-delinted seed since cracked seed were eliminated by hand picking and internally infected seed were likely to be discarded in the washing and grading process.

TABLE 5.—Effectiveness of seed treatment in bacterial blight control; field tests.*

Variety and Replication	Treated		Nontreated		Average
	Number Diseased	Percent Diseased	Number Diseased	Percent Diseased	
Stoneville 2B-1	0	0	32	16.0 }	
Stoneville 2B-2	0	0	27	13.5 }	14.75
Deltapine 14-1	0	0	35	17.5 }	
Deltapine 14-2	0	0	42	21.0 }	19.25

* Based on 200 plants selected at random.

TABLE 6.—Effectiveness of seed treatment in bacterial blight control; greenhouse tests.

Variety Hi-Bred	Treated			Nontreated		
	Replications			Replications		
	1	2	3	1	2	3
Number healthy	130	145	137	106	108	112
Number diseased	0	2	1	18	24	23
Percent diseased	0	1.4	0.7	14.5	18.2	17.0

Conclusions

Although several kinds of fungi are associated with boll rotting and lint deterioration, some of them being of very frequent occurrence, it has been demonstrated by pathogenicity tests that these fungi are secondary invaders of bolls. Some sort of injury to the boll, such as insect punctures or primary invasion by the bacterial blight parasite, must take place before these various other organisms can begin their destructive work. The importance of the blight lesions as the first step in the rotting process should be emphasized, since it is largely by means of these primary lesions that the secondary fungi gain entrance into the boll tissues. The role of the bacterium as a direct cause of rotting is not great, since the bacterial lesions develop slowly, are shallow and frequently do not penetrate into the lint cavity. The actual extensive rotting of boll tissues can be attributed almost entirely to the secondary fungus invaders. Some of these organisms, such as *Aspergillus niger*, *Rhizopus nigricans*, *Alternaria* spp., and *Glomerella gossypii*, caused a very rapid deterioration of the lint and seed, whereas other fungi investigated were considerably slower in their rotting activities.

Because of the key position of the bacterial blight pathogen in the boll rot complex, it logically follows that control of this pathogen would be an important means of reducing boll rotting. Seed treatment by acid-delinting alone or plus the addition of a satisfactory chemical dust, or the dusting of fuzzy seed, have provided excellent control of blight in the seedling stage.

SUMMARY

1. Pathogenicity tests showed that the bacterial blight pathogen was the only organism among those tested that could invade bolls without the aid of some mechanical injury.
2. Nearly all of the fungi causing boll rots were discovered to be associated with bacterial lesions through which they gained entrance into the boll tissues.
3. The anthracnose fungus, the principal cause of boll rots in the southeastern part of the Cotton Belt, was found occurring very rarely in Oklahoma and only along the eastern border.
4. *Rhizopus nigricans* and *Aspergillus niger* rotted bolls more completely and more rapidly than the other organisms tested. All of the fungi, with the exception of *Rhizopus*, pro-

duced a more rapid deterioration of the internal boll tissues than the external.

5. *Alternaria* spp., although not the most rapid rotter, occurred more frequently than any other fungus and consequently is considered to be the most important cause of boll rotting by fungi in Oklahoma.

6. In the dry summer of 1943, boll rots were infrequent, due primarily to the failure of the bacterial organism to develop under such conditions. In the wetter summers of 1942 and 1944, bacterial blight was abundant and subsequently so were the secondary boll-rotting fungi.

7. The key to control of boll rots is control of the bacterial blight disease. Acid-delinting with or without the application of a suitable chemical dust and the treatment of fuzzy seed with a satisfactory chemical dust, have provided excellent control of the disease in the seedling stage.

8. The appearance of blight from mid-season until harvest in a field planted with treated seed creates a control problem which has not as yet been solved. The breeding of resistant varieties has begun and the solution of the problem may be forthcoming.

LITERATURE CITED

1. Barre, H. W. Cotton anthracnose investigations. S. C. Agr. Exp. Sta. Report 22: 89-118. 1909.
2. Blodgett, F. H. Relation between storm and disease, August and September, in Texas. (Abstr.) Phytopath. 6: 100-101. 1916.
3. Brown, J. G. Black-arm of cotton: A successful method of control. Ariz. Agr. Exp. Sta. Timely Hints for Farmers 142. 1922.
4. Edgerton, C. W. The rots of the cotton boll. La. Agr. Exp. Sta. Bull. 137. 1912.
5. _____ Flower infection with cotton boll rots. Phytopath. 2: 23-27. 1912.
6. Faulwetter, R. C. Wind-blown rain a factor in disease dissemination. Jour. Agr. Res. 10: 639-648. 1917.
7. Kirkpatrick, T. W. Notes on the fungus *Rhizopus nigricans* Ehr., in relation to insect pests of the cotton plant in Egypt. Egypt. Min. Agr. Tech. and Sci. Serv. Bull. 54: 1-28. 1925.
8. Miles, L. E. Angular leaf spot of cotton. Miss. Agri. Exp. Sta. Inform. Sheet 48. July 1943.
9. Miller, P. R. A survey of cotton boll rot diseases and the fungi associated with them. Pl. Dis. Repr. 23: 29-32. 1939.
10. _____ A summary of four years of cotton seedling and boll rot disease surveys. Pl. Dis. Repr. Suppl. 141: 54-58. 1943.
11. _____ and R. Weindling. A survey of cotton boll rot diseases in 1939 and the microorganisms associated with them. Pl. Dis. Repr. 23: 329-334. 1939.
12. _____ and _____. A survey of cotton boll rot diseases in 1940 and the microorganisms connected with them. Pl. Dis. Repr. 24: 417-423. 1940.
13. _____ and _____. A survey of cotton boll rot diseases and associated microorganisms in 1941. Pl. Dis. Repr. 25: 519-521. 1941.
14. Ray, W. W. Cotton boll rots and the fungi associated with them in Oklahoma in 1942. Pl. Dis. Repr. 26: 473-474. 1942.
15. _____ Cotton boll rots and the fungi associated with them in Oklahoma in 1944. Pl. Dis. Repr. 28: 981-982. 1944.
16. _____ and J. H. McLaughlin. Isolation and infection tests with seed, and soil-borne cotton pathogens. Phytopath. 32: 233-238. 1942.
17. Rolfs, F. M. Angular leaf spot of cotton. S. C. Agr. Exp. Sta. Bull. 184: 1-30. 1915.
18. Shapovalov, M. The two most common decays of cotton bolls in the Southwestern States. Jour. Agr. Res. 35: 307-312. 1927.
19. Smith, E. F. The bacterial disease of plants. Saunders Co., Philadelphia, pp. 314-339. 1920.
20. Stoughton, R. H. The influence of environmental conditions on the development of the angular leaf-spot disease of cotton. Ann. Appl. Biol. 15: 333-341. 1928.
21. _____ The influence of environmental conditions on the development of the angular leaf-spot disease of cotton. IV. The influence of atmospheric humidity on infection. Ann. Appl. Biol. 19: 370-377. 1932.
22. Weindling, R. and P. R. Miller. Relation of *Bacterium malvacearum* to anthracnose boll rot of cotton. (Abstr.) Phytopath. 31: 24. 1941.
23. Wiltshire, S. P. The foundation species of *Alternaria* and *Macrocosprium*. Trans. Brit. Myc. Soc. 18: 135-160. 1933.

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